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and percolation are represented by only about 30% as against 50% of that volume. As stated above, it remains to be determined by the observations of many future years whether there is a tendency to a normal variation in annual rainfall upon the Isthmus, as seems to be suggested by the figures already of record.

[1] In a paper which appeared in *Professional Memoirs, Corps of Engineers, U.S.A.*, for November-December, 1915.

THE METEOR SYSTEM OF PONS-WINNECKE'S COMET

By Charles P. Olivier

LEANDER McCORMICK OBSERVATORY, UNIVERSITY OF VIRGINIA

Communicated by E. W. Morley and read before the Academy, November 14, 1916

The National Academy of Sciences, by two grants from the J. Lawrence Smith Fund, having been the means of greatly extending the membership and work of the American Meteor Society, it seems well to report to the Academy the most interesting single result of the work so far obtained.

Late in May and early in June of this year two of our observers, Mr. John Koep and Mr. Philip Trudelle, both of Chippewa Falls, Wis., sent in a series of observations which showed that meteors were at least three times as numerous as is usual for the time of the year mentioned. This attracted immediate attention and the observations were worked up without delay. The orbits, which corresponded to the positions found for the radiants, were then computed. As several of the orbits turned out to have the same elements, a search was next made to see if any of the known comets had a similar orbit.

At once it was seen that Pons-Winnecke's Comet fulfilled the conditions excellently and there was no doubt that the meteors and the comet had a common origin, and that another case of the connection between a meteor stream and a comet had been found.

The first orbits for the meteors had been computed on the usual assumption that they moved with a parabolic velocity, but there were obvious reasons to show that this was only a first approximation. The orbits were then all computed as elliptical, assuming their major axes equal to that of the comet. This set made a far better agreement with the elements of the comet's orbit and put the connection beyond question.

Before speaking further about the meteors themselves, it will be of interest to review briefly the history of this rather remarkable comet. Discovered by Pons in 1819, no further observations were obtained until

ELLIPTICAL ELEMENTS							PARABOLIC ELEMENTS								
No.	Log a	Log e	Log q	i	P	N	No.	Date	R A	Decl.	i	Log q	P	N	Obs.
1	0.514	9.857	9.962	16.7	280.1	60.7	1	May 21.6	224.5	25.2	20.2	9.954	279.7	60.7	J. K.
2	0.514	9.865	9.948	18.6	287.6	65.5	2	26.68	230.3	27.4	22.4	9.958	283.4	65.5	P. T.
3	0.514	9.854	9.970	17.6	282.6	66.1	3	27.25	231.0	27.5	22.5	9.958	284.2	66.1	J. K.
4	0.514	9.856	9.964	19.0	286.2	66.5	4	27.67	232.1	26.8	22.8	9.954	285.4	66.5	P T.
5	0.514	9.855	9.996	19.1	285.6	68.0	5	29.2	232.7	28.0	22.9	9.960	284.9	68.0	J. K.
6	0.514	9.852	9.974	17.6	287.6	73.2	6	June 3.7	234.4	27.5	22.2	9.965	288.4	73.2	J. K
7	0.514	9.855	9.967	18.2	291.6	74.2	7	4.68	235.8	25.6	22.0	9.961	291.0	74.2	P. T.
8	0.514	9.839	0.005	17.1	268.3	96.9	8	28.5	203.0	53.0	20.9	0.005	268.3	96.0	B
Comet	0.514	9.846	9.988	18.3	271.6	99.3									

1858 when it was rediscovered and named after Winnecke. Since then it has been seen in 1869, 1875, 1886, 1892, 1898, 1909, and 1915. While it has never been a bright comet, at its last return—a rather unfavorable one it is true—it never surpassed the twelfth magnitude in brightness and was more than a unit's distance from the earth. The comet belongs to Jupiter's family and at present has a major axis of about 6.52 astronomical units and a period of 5.89 years.

Since at certain epochs it has passed very near Jupiter, the most massive of the planets, the elements of its orbit have been changed in a most marked manner due to perturbations caused by that body. Briefly from 1858 to 1909 its longitude of perihelion has changed from 276° to 272°, its ascending node from 114° to 99°, the eccentricity of its orbit from 0.76 to 0.70, and finally its perihelion distance from 0.70 to 0.97 astronomical unit. This last change is the one of greatest importance for the present discussion, because it made possible the intersection of the earth's orbit with those of the meteors connected with the comet.

It will be seen that this element was slowly increasing during this interval of 51 years, and hence, if the progression continued in the same direction, in the seven years since 1909 it should have reached the value unity almost exactly, which means that the nodal point was indeed very near to the earth when the latter passed by it, late in June. While the inclination of the comet's orbit has increased from 11° in 1858 to 18° in 1909, still the extreme distances between the earth and the comet's 1909 orbit was only about 14,000,000 miles on May 25, and this decreased to 2,000,000 on June 28. Even this first figure is not excessive, because we already have positive proof that members of the Perseid and Aquarid streams have been observed at about that distance from the orbit of the parent comet.

The longitudes of the nodes differ considerably. This is due to the fact that this element of a meteor's orbit depends merely upon the position of the earth in its orbit, and when the agreement of the other elements is satisfactory, considerable differences in the node mean little. It will be seen that the other elements agree very well indeed, remembering the limit of accuracy possible in work on meteors, which is never comparable in this regard to results obtained with the telescope.

The data on which final conclusions were based are rather extensive. For America we had about 1100 observations reported by five of our members during the interval these meteors were seen, and three English observers also published results about the time of maximum, which are available. Eight orbits were calculated from this material, a number quite sufficient to illustrate the general agreement and order of accuracy of the work. Several others have since been computed. Of course in the final discussion all the data will be included and published in full detail.

While the working up of the American observations and the conclusions drawn from them are of course my own, yet I desire to make full acknowledgment to Messrs. Koep and Trudelle, through whose enthusiastic and excellent observing my part was made possible. Their work is of a high order, and it may be said that in 1916, from January to September, Mr. Koep sent in about 1800 observations and Mr. Trudelle about 1330.

It is only just to say that Mr. W. F. Denning of Bristol, England, observed these meteors and later published his observations, saying that the meteors moved in orbits somewhat similar to that of Pons-Winnecke's comet and they might possibly be connected. He gave no elements nor did he state on what sort of investigations his inference was based.

However, he published this before I sent my results to Harvard College Observatory, for publication in one of its *Bulletins*, but the journal containing Mr. Denning's results had not then arrived from England and I was ignorant of his conclusions.

Finally the members of the National Academy of Sciences will be interested to learn that since the first grant from the J. Lawrence Smith Fund became available last year no less than 5000 observations of meteors made by members of the American Meteor Society were sent in during 1915, and 7500 more were received up to October 1 of this year.